

FIRST DRAFT

CLASSIFICATION SCHEME FOR BENTHIC HABITATS: US PACIFIC TERRITORIES

FIRST DRAFT



NOAA National Ocean Service
National Centers for Coastal Ocean Science
Center for Coastal Monitoring and Assessment
Biogeography Program

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DEVELOPED IN COOPERATION WITH FEDERAL, STATE, ACADEMIC, & PRIVATE
SECTOR PARTNERS FOR THE DEVELOPMENT OF PACIFIC ISLAND DIGITAL
BENTHIC HABITAT MAPS IN RESPONSE TO THE US CORAL REEF TASK FORCE
NATIONAL ACTION PLAN

ABOUT THIS DOCUMENT

This document was produced to support the U.S. Coral Reef Task Force (CRTF), created by Executive Order P.L. 13089, which calls for the conservation and protection of the nation's coral reefs. The *Classification Scheme for Benthic Habitats: US Pacific Territories* complements The *Classification Scheme for Benthic Habitats: Main Eight Hawaiian Islands* (Coyne et al. 2001) and chapter one, Classification Scheme for Benthic Habitats, of the document *Methods Used to Map the Benthic Habitats of Puerto Rico and the U.S. Virgin Islands*, (Kendall et al. 2001).

BACKGROUND

The National Oceanic and Atmospheric Administration (NOAA) National Ocean Service (NOS) initiated a coral reef research program in 1999 to map, assess, inventory, and monitor U.S. coral reef ecosystems. These activities were implemented in response to requirements outlined in the *Mapping Implementation Plan* developed by the Mapping and Information Synthesis Working Group (MISWG) of the CRTF (MISWG 2000). As part of the MISWG of the CRTF, NOS' Biogeography Team has been charged with the development and implementation of a plan to produce comprehensive digital coral-reef ecosystem maps for all U.S. States, Territories, and Commonwealths within five to seven years. Joint activities between Federal agencies are particularly important to map, research, monitor, manage, and restore coral reef ecosystems. In response to the Executive Order, NOS is conducting research to digitally map biotic resources and coordinate a long-term monitoring program that can detect and predict change in U.S. coral reefs, and their associated habitats and biological communities.

Until now, most U.S. coral reef resources have not been digitally mapped at a scale or resolution sufficient for assessment, monitoring, and/or research to support resource management. Thus, a large portion of NOS's coral reef research activities have focused on mapping of U.S. coral reef ecosystems. The map products will provide the fundamental spatial organizing framework to implement and integrate research programs and the capability to effectively communicate information and results to coral reef ecosystem managers. Although the NOS coral program is relatively young, it has had tremendous success in advancing towards the goal to protect, conserve, and enhance the health of U.S. coral reef ecosystems. One objective of the program was to create benthic habitat maps to support coral reef research to enable development of products that support management needs and questions. An initial step in producing benthic habitat maps is the development of a habitat classification scheme. The purpose of this document is to outline the benthic habitat classification scheme for the US Territories in the Pacific: American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI). This document may be modified to include the Federated States of Micronesia (FSM), Republic of Palau and the Marshall Islands if funding becomes available to map those areas.

This classification scheme will be used in the applied mapping component of the overall project. Benthic habitat maps will be created by visual interpretation of digital imagery using "heads up" (on screen) computer digitizing. The imagery must be of sufficient quality to enable visual interpretation into classified habitat maps. Regardless of the type of imagery collected (i.e., photographic, hyperspectral, satellite), it will need to be classified into distinct categories that meet the needs of both the management and scientific community. Developing this classification scheme is an important step in determining the type of map products to be produced from the imagery. To facilitate development of the digital benthic habitat maps, NOAA and its partners have produced a classification manual (*Methods Used to Map the Benthic Habitats of Puerto Rico and the U.S. Virgin Islands*) that will document the specific methods used in image interpretation and habitat classification (Kendall et al. 2001). Chapters of the classification manual include a list of the classified habitats, description of the habitats, guidelines for on-screen mapping, and an assessment of classification accuracy.

Please continue to monitor the progress of this work on NCCOS's Biogeography Program website:
(<http://biogeo.nos.noaa.gov/>)

DEVELOPING THE HABITAT CLASSIFICATION SCHEME

A hierarchical classification scheme is being created to define and delineate habitats. The classification scheme will be influenced by many factors including: requests from the management community, NOS's coral reef mapping experience in the Florida Keys and Caribbean, existing classification schemes for the Pacific and Hawaiian Islands (State of Hawaii 1981; Holthus and Maragos 1995; Gulko 1998; Allee et al. unpublished), other coral reef systems (Kruer 1995; Reid and Kruer 1998; Lindeman et al. 1998; Shepard et al. 1995; Vierros 1997; Chauvaud et al. 1998; Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute and NOAA, 1998; Mumby et al. 1998; NOAA et al. 1998), quantitative habitat data from the islands, the minimum mapping unit (MMU - i.e., 1 acre for visual photointerpretation), and analysis of the spatial and spectral limitations of aerial photography and hyperspectral imagery. The hierarchical scheme will allow users to expand or collapse the thematic detail of the resulting map to suit their needs. This is an important aspect of the scheme as it will provide a "common language" to compare and contrast digital maps developed from complementary remote sensing platforms. Furthermore, it is encouraged that additional hierarchical categories be added in the resulting geographic information system by users with more detailed knowledge or data for specific areas. For example, habitat polygons smaller than the MMU can be delineated, such as habitat polygons delineated as colonized pavement using this scheme could be further attributed with health information (i.e., bleached, percent live cover) or species composition (i.e., *Porites*, *Montipora*).

GENERAL DESCRIPTION OF THE CLASSIFICATION SCHEME

The classification scheme defines benthic communities on the basis of two attributes: large geographic "zones" which are composed of smaller "habitats". Zone refers only to benthic community location and habitat refers only to substrate and/or cover type. Every polygon on the benthic community map will be assigned a habitat within a zone (e.g. sand in the lagoon, or sand on the bank). Zone indicates polygon location and habitat indicates composition of each benthic community delineated. Combinations of habitat and zone that are analogous to traditionally used terminology will be noted where appropriate. The description of each zone and habitat will include example images. Where available, both underwater and aerial photographs will be included for habitats. Aerial images will be included for zones. The zone/habitat approach to the classification scheme was developed by the Caribbean Fishery Management Council; Dr. Ken Lindeman, Environmental Defense; and the NOS Biogeography Team.

Eleven mutually exclusive zones have been identified from land to open water corresponding to typical insular shelf and coral reef geomorphology (Fig. 1-2). These zones include: land, vertical wall, shoreline intertidal, lagoon, reef flat, back reef, reef crest, fore reef, bank/shelf, bank/shelf escarpment, channel, and dredged (since this condition eliminates natural geomorphology). Zone refers only to each benthic community's location and does not address substrate or cover types within. For example, the lagoon zone may include patch reefs, sand, and seagrass beds; however, these are considered structural elements that may or may not occur within the lagoon zone and therefore, are not used to define it. Twenty-seven distinct and non-overlapping habitat types have been identified that can be mapped by visual interpretation of remotely collected imagery. Habitats or features that cover areas smaller than the MMU (TBD) will not be considered. For example, sand halos surrounding patch reefs are too small to be mapped independently. Habitat refers only to each benthic community's substrate and/or cover type and does not address location on the shelf. Habitats are defined in a collapsible hierarchy ranging from four broad classes (unconsolidated sediment, submerged vegetation, coral reef and hardbottom, and other), to more detailed categories (e.g., emergent vegetation, seagrass, algae, individual patch reefs, uncolonized volcanic rock), to patchiness of some specific features (e.g., 50-90 percent cover of macroalgae).

LIST OF ZONES AND HABITATS

ZONES

Land
Shoreline Intertidal
Vertical Wall*
Lagoon
Back Reef (w/ Lagoon, see barrier reef - Figure 1)
Reef Flat (w/o Lagoon, see fringing reef - Figure 2)
Reef Crest
Fore Reef
Bank/Shelf
Bank/Shelf Escarpment
Channel*
Dredged*
Unknown

*not depicted in figures

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ZONE CROSS-SECTIONS

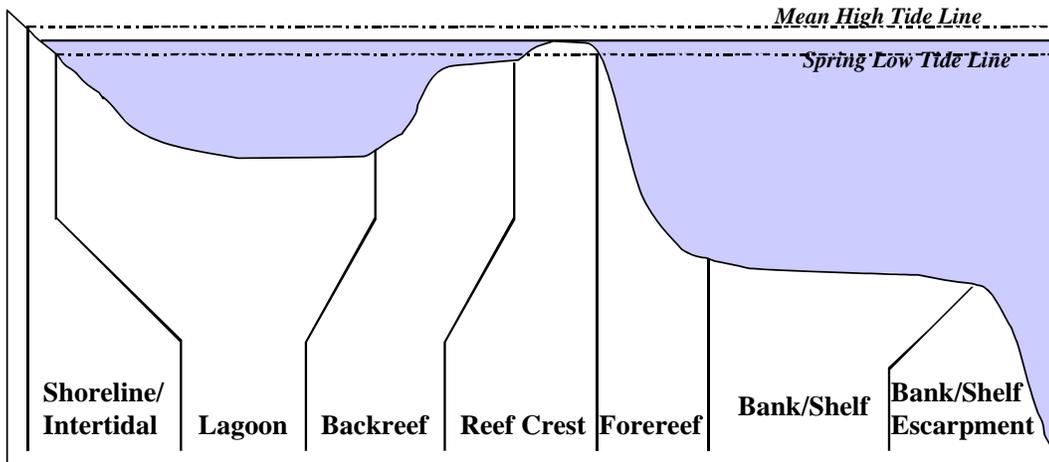


Figure 1. Barrier reef cross-section. Reef separated from the shore by a relatively wide, deep lagoon.

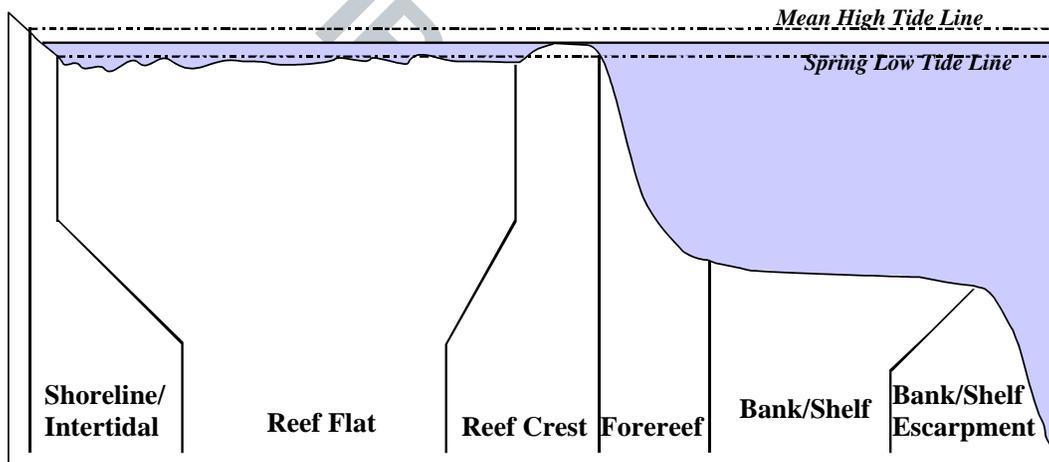


Figure 2. Fringing Reef cross-section. Reef platform is continuous with the shore.

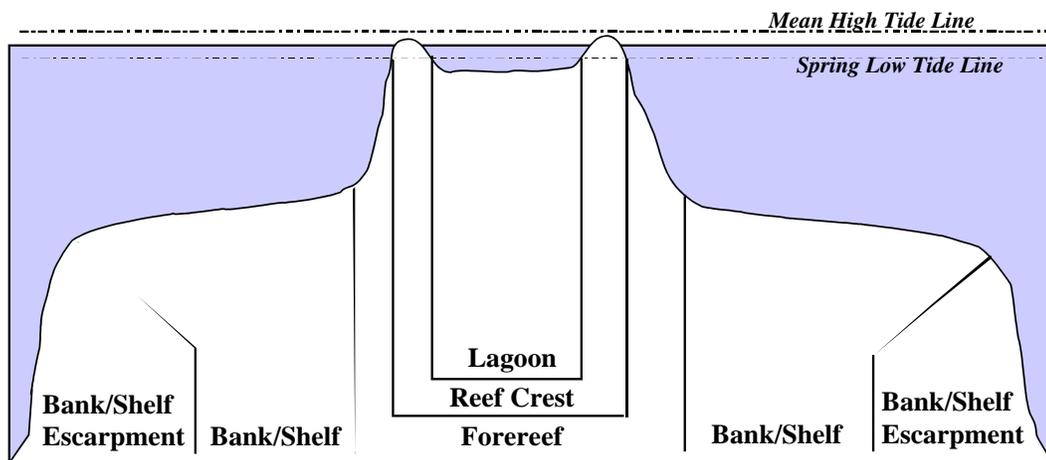


Figure 3. Atoll cross-section. Reef surrounding a lagoon.

HABITATS

Unconsolidated Sediment (0%-<10% submerged vegetation)

- Mud
- Sand

Submerged Vegetation

Seagrass

- Continuous Seagrass (90%-100% Cover)
- Patchy (Discontinuous) Seagrass (50%-<90% Cover)
- Patchy (Discontinuous) Seagrass (10%-50% Cover)

Macroalgae (fleshy and turf)

- Continuous Macroalgae (90%-100% Cover)
- Patchy (Discontinuous) Macroalgae (50%-<90% Cover)
- Patchy (Discontinuous) Macroalgae (10%-<50% Cover)

Coral Reef and Hardbottom

Coral Reef and Colonized Hardbottom

- Linear Reef
- Aggregated Coral
- Spur and Groove
- Individual Patch Reef
- Aggregated Patch Reef
- Scattered Coral/Rock in Unconsolidated Sediment
- Colonized Pavement
- Colonized Volcanic Rock/Boulder
- Colonized Pavement with Sand Channels

Uncolonized Hardbottom

- Reef Rubble
- Uncolonized Pavement
- Uncolonized Volcanic Rock/Boulder
- Uncolonized Pavement with Sand Channels

Encrusting/Coralline Algae

- Continuous Encrusting/Coralline Algae (90%-100% Cover)
- Patchy (Discontinuous) Encrusting/Coralline Algae (50%-<90% Cover)
- Patchy (Discontinuous) Encrusting/Coralline Algae (10%-<50% Cover)

Other Delineations

- Land
- Emergent Vegetation
- Artificial
- Unknown

Zones

DESCRIPTION OF ZONES AND HABITATS:

Shoreline Intertidal: Area between the mean high water line (or landward edge of emergent vegetation when present) and lowest spring tide level (excluding emergent segments of barrier reefs). Typically, this zone is narrow due to the small tidal range in the main eight Hawaiian Islands.

Typical Habitats: Mangrove, hao, sand, seagrass, and uncolonized volcanic/carbonate rock.



Vertical Wall: Area with near-vertical slope from shore to shelf or shelf escarpment. This zone is typically narrow and may not be distinguishable in remotely gathered imagery, but is included because it is recognized as a biologically important feature.

Typical Habitats: volcanic rock, algae, coral.



Lagoon: Shallow area (relative to the deeper water of the bank/shelf) between the shoreline intertidal zone and the back reef of a reef or a barrier island. This zone is protected from the high-energy waves commonly experienced on the bank/shelf and reef crest. If no reef crest is present there is no lagoon zone.

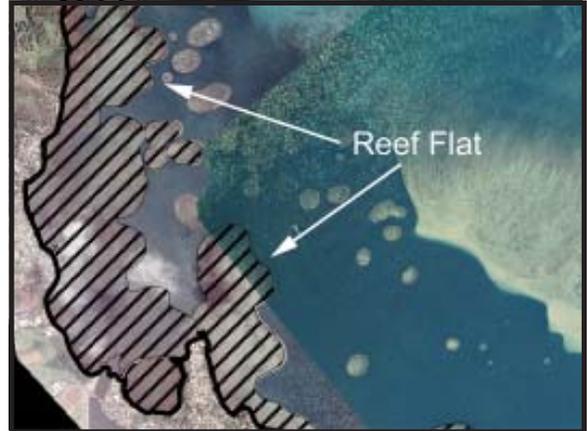
Typical Habitats: Sand, seagrass, algae, pavement, volcanic/carbonate rock, and patch reefs.



Zones

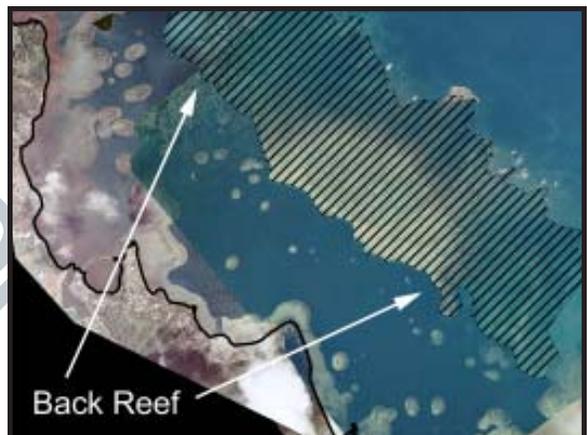
Reef Flat: Shallow (semi-exposed) area between the shoreline intertidal zone and the reef crest of a fringing reef. This zone is protected from the high-energy waves commonly experienced on the shelf and reef crest. Reef flat is typically not present if there is a lagoon zone.

Typical Habitats: Sand, reef rubble, seagrass, algae, and patch reef.



Back Reef: Area between the seaward edge of a lagoon floor and the landward edge of a reef crest. This zone is present when a reef crest and lagoon exist.

Typical Habitats: Sand, reef rubble, seagrass, algae, linear reef, and patch reef.



Reef Crest: The flattened, emergent (especially during low tides) or nearly emergent segment of a reef. This zone lies between the back reef and fore reef zones. Breaking waves will often be visible in aerial images at the seaward edge of this zone.

Typical Habitats: Reef rubble, linear reef., and aggregated coral.



Zones

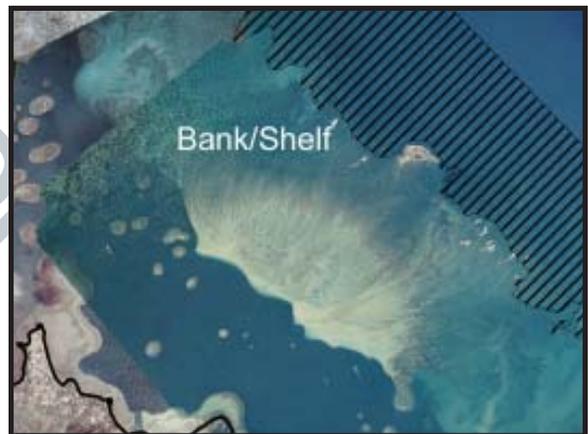
Fore Reef: Area from the seaward edge of the reef crest that slopes into deeper water to the landward edge of the bank/shelf platform. Features not forming an emergent reef crest but still having a seaward-facing slope that is significantly greater than the slope of the bank/shelf are also designated as fore reef (Fig. 2).

Typical Habitats: Linear reef and Spur and Groove.



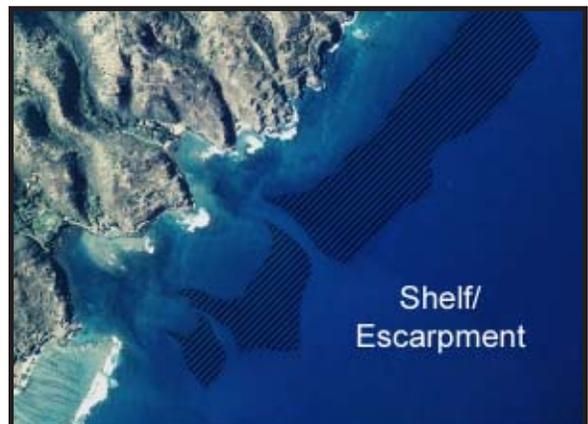
Bank/Shelf: Deep water area (relative to the shallow water in a lagoon) extending offshore from the seaward edge of the fore reef to the beginning of the escarpment where the insular shelf drops off into deep, oceanic water. The bank/shelf is the flattened platform between the fore reef and deep open ocean waters or between the shoreline/intertidal zone and open ocean if no reef crest is present.

Typical Habitats: Sand, patch reefs, algae, seagrass, linear reef, colonized and uncolonized pavement, colonized and uncolonized pavement with sand channels, and other coral reef habitats.



Shelf Escarpment: The edge of the bank/shelf where depth increases rapidly into deep, oceanic water. This zone begins at approximately 20 to 30 meters depth, near the depth limit of features visible in aerial images. This zone extends well into depths exceeding those that can be seen on aerial photographs and is intended to capture the transition from the shelf to deep waters of the open ocean.

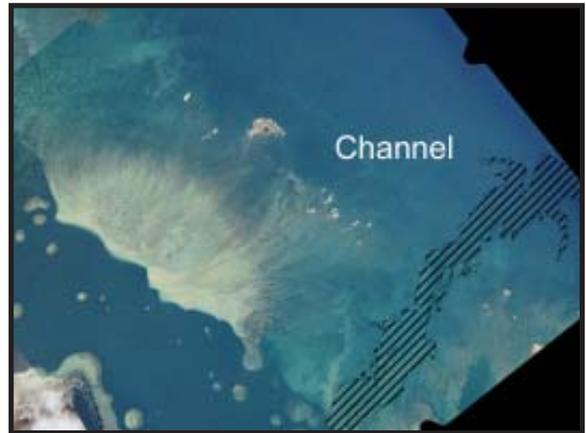
Typical Habitats: Sand, linear reef, and spur and groove.



Zones

Channel: Naturally occurring channels that often cut across several other zones.

Typical Habitats: Sand, mud, uncolonized pavement.



Dredged: Area in which natural geomorphology is disrupted or altered by excavation or dredging.

Typical Habitats: Sand, mud.



Unknown: Zone uninterpretable due to turbidity, cloud cover, water depth, or other interference.



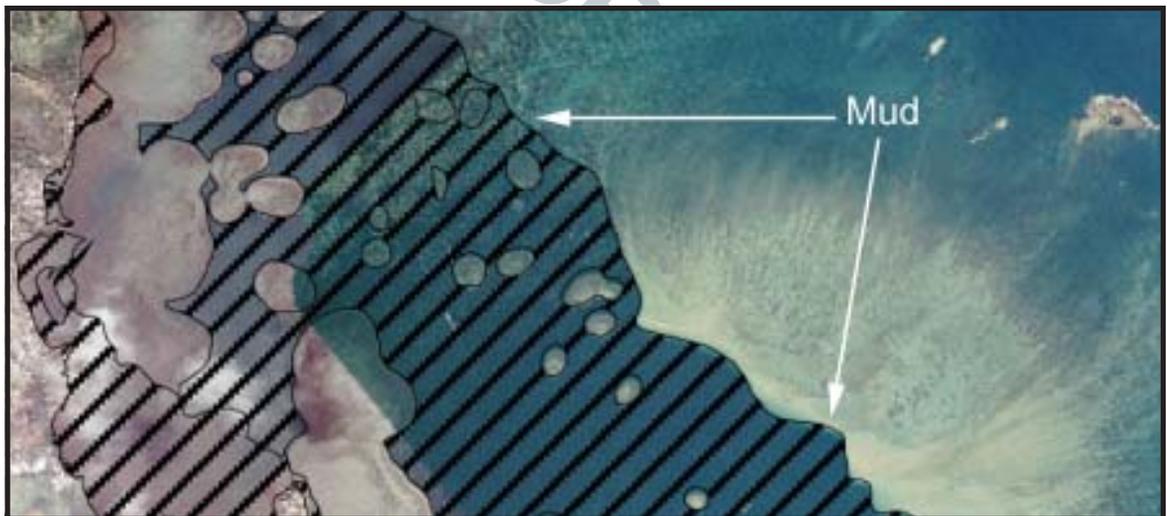
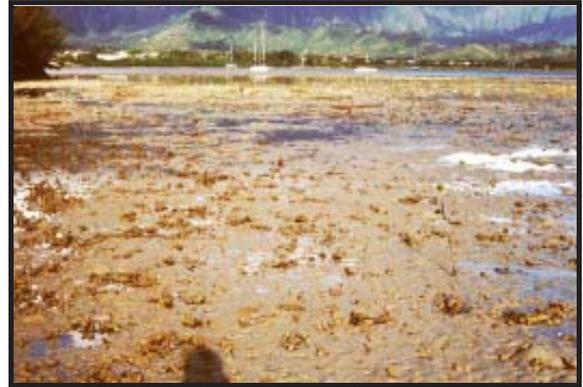
Habitats

Mud

Unconsolidated Sediment: Unconsolidated sediment with less than 10 percent cover of submerged vegetation.

Mud: Fine sediment often associated with river discharge and buildup of organic material in areas sheltered from high-energy waves and currents.

Unconsolidated Sediment

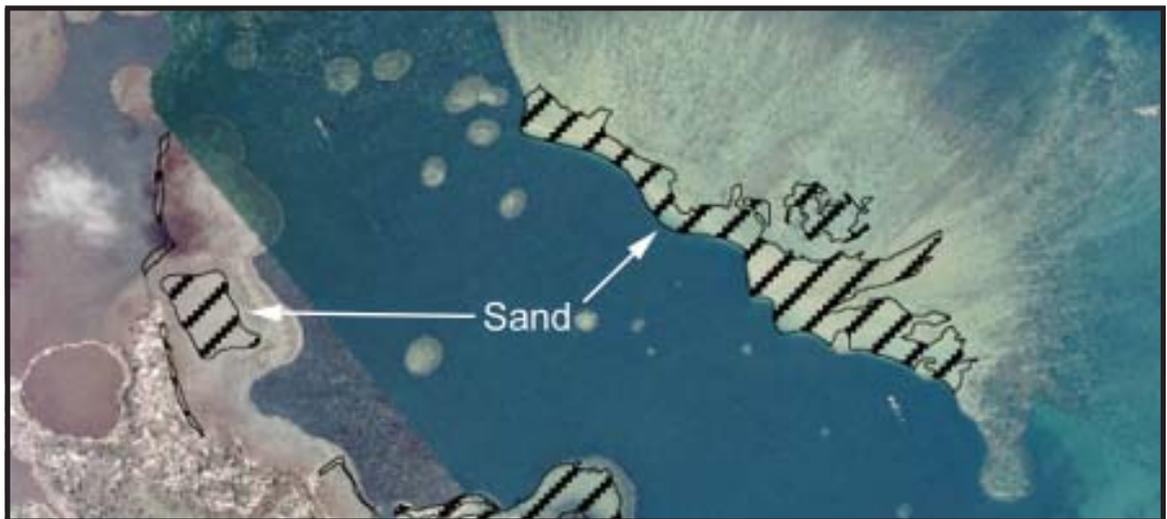
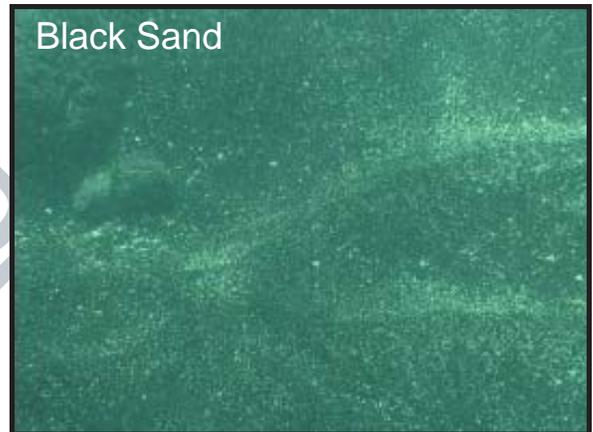
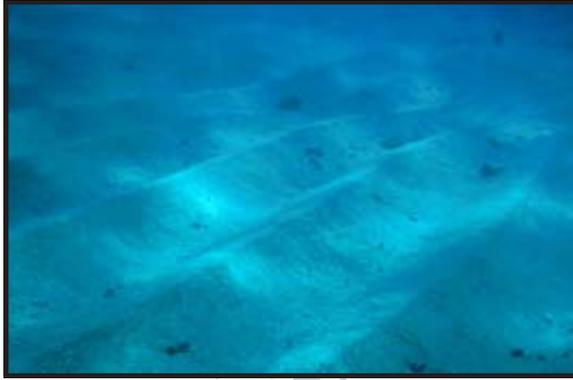


Habitats

Sand

Sand: Coarse sediment typically found in areas exposed to currents or wave energy.

Unconsolidated Sediment



Seagrass

Submerged Vegetation: Greater than 10 percent cover of submerged vegetation in unspecified substrate type (usually sand, mud, or hardbottom).

Seagrass: Habitat with 10 percent or more cover of seagrass (e.g., *Halophila sp.*).

Continuous Seagrass: Seagrass covering 90 percent or more of the substrate. May include blowouts of less than 10% of the total area that are too small to be mapped independently (less than the MMU). This includes continuous beds of any shoot density (may be a continuous sparse or dense bed).

Patchy Seagrass: Discontinuous seagrass with breaks in coverage that are too diffuse or irregular, or result in isolated patches of seagrass that are too small (less than the MMU) to be mapped as continuous seagrass.

Patchy Seagrass (50%-90% cover)

Patchy Seagrass (10%-50% cover)

Representative Species:

Halophila sp.



Macroalgae

Macroalgae: An area with 10 percent or greater coverage of any combination of numerous species of red, green, or brown macroalgae. Usually occurs in shallow backreef and deeper waters on the bank/shelf zone. High relief (hardbottom) habitats takes precedence over macroalgae cover.



Continuous Macroalgae: Macroalgae covering 90 percent or greater of the substrate. May include blowouts of less than 10 percent of the total area that are too small to be mapped independently (less than the MMU). This includes continuous beds of any density (may be a continuous sparse or dense bed).

Patchy Macroalgae: Discontinuous macroalgae with breaks in coverage that are too diffuse or irregular, or result in isolated patches of macroalgae that are too small (smaller than the MMU) to be mapped as continuous macroalgae.

Patchy Macroalgae (50%-<90% cover)

Patchy Macroalgae (10%-<50% cover)

Representative Species:

Dictyosphaeria spp.

Submerged Vegetation



Linear Reef

Coral Reef and Hardbottom: Hardened substrate of unspecified relief formed by the deposition of calcium carbonate by reef building corals and other organisms (relict or ongoing) or existing as exposed bedrock or volcanic rock.

Coral Reef and Colonized Hardbottom: Substrates formed by the deposition of calcium carbonate by reef building corals and other organisms. Habitats within this category have some colonization by live coral, unlike the uncolonized hardbottom category.



Linear Reef: Linear coral formations that are oriented parallel to shore or the shelf edge. These features follow the contours of the shore/shelf edge. This category is used for such commonly used terms as fore reef, fringing reef, and shelf edge reef.

Coral Reef and Hardbottom



Habitats

Aggregated Coral

Aggregated Coral: Coral-dominated formations with high relief and structural complexity. Often serve same role as linear reef habitat in fringing reef systems where the reef crest is relatively unorganized.

Coral Reef and Hardbottom



Spur and Groove

Spur and Groove: Habitat having alternating sand and coral formations that are oriented perpendicular to the shore or bank/shelf escarpment. The coral formations (spurs) of this feature typically have a high vertical relief relative to pavement with sand channels (see below) and are separated from each other by 1-5 meters of sand or bare hardbottom (grooves), although the height and width of these elements may vary considerably. This habitat type typically occurs in the fore reef or bank/shelf escarpment zone.

Coral Reef and Hardbottom



Patch Reefs

Patch Reef(s): Coral formations that are isolated from other coral reef formations by sand, seagrass, or other habitats and that have no organized structural axis relative to the contours of the shore or shelf edge.

Individual patch reef: Distinctive single patch reefs that are larger than or equal to the MMU.



Aggregate patch reefs: Clustered patch reefs that individually are too small (less than the MMU) or are too close together to map separately.

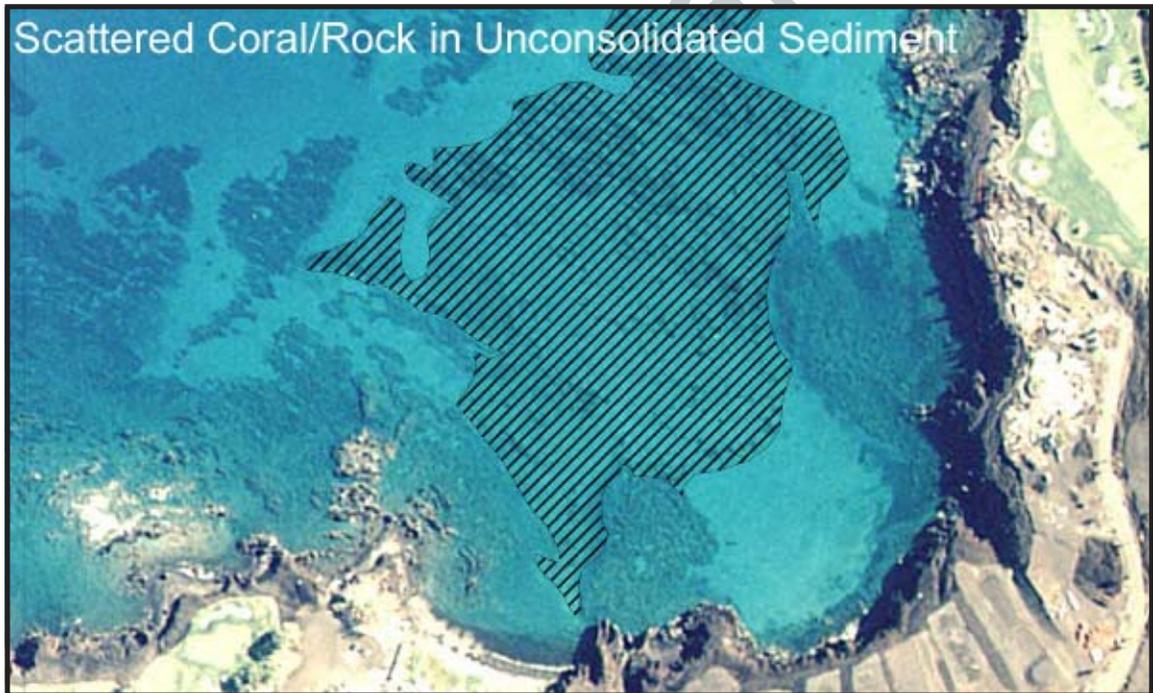


Habitats

Scattered Coral/Rock in Unconsolidated Sediment

Scattered Coral/Rock in Unconsolidated Sediment: Primarily sand or seagrass bottom with scattered rocks or small, isolated coral heads that are too small to be delineated individually (i.e. smaller than individual patch reef).

Coral Reef and Hardbottom

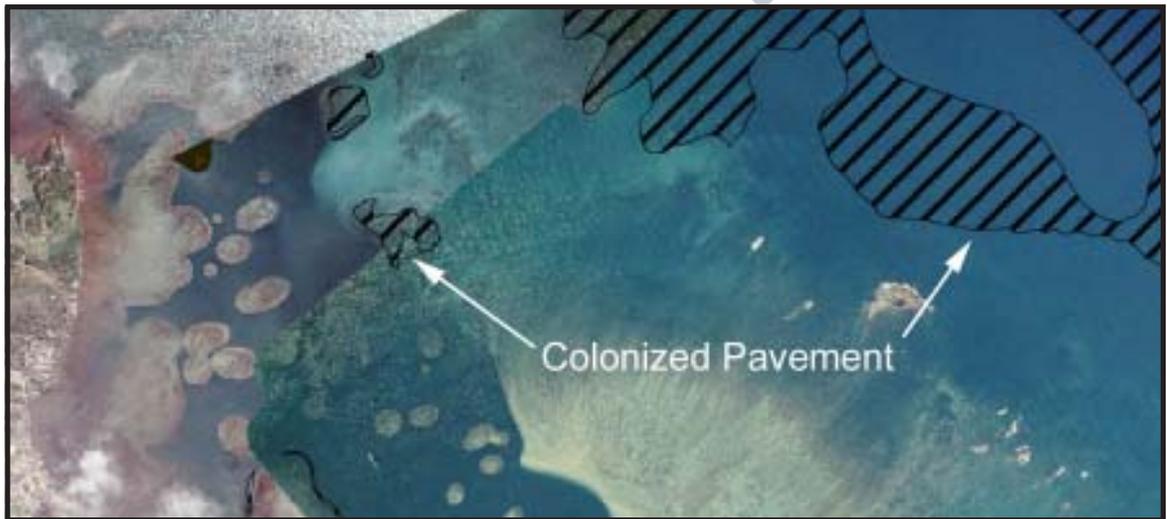


Habitats

Colonized Pavement

Colonized Pavement: Flat, low-relief, solid carbonate rock with coverage of macroalgae, hard coral, zoanthids, and other sessile invertebrates that are dense enough to begin to obscure the underlying surface.

Coral Reef and Hardbottom

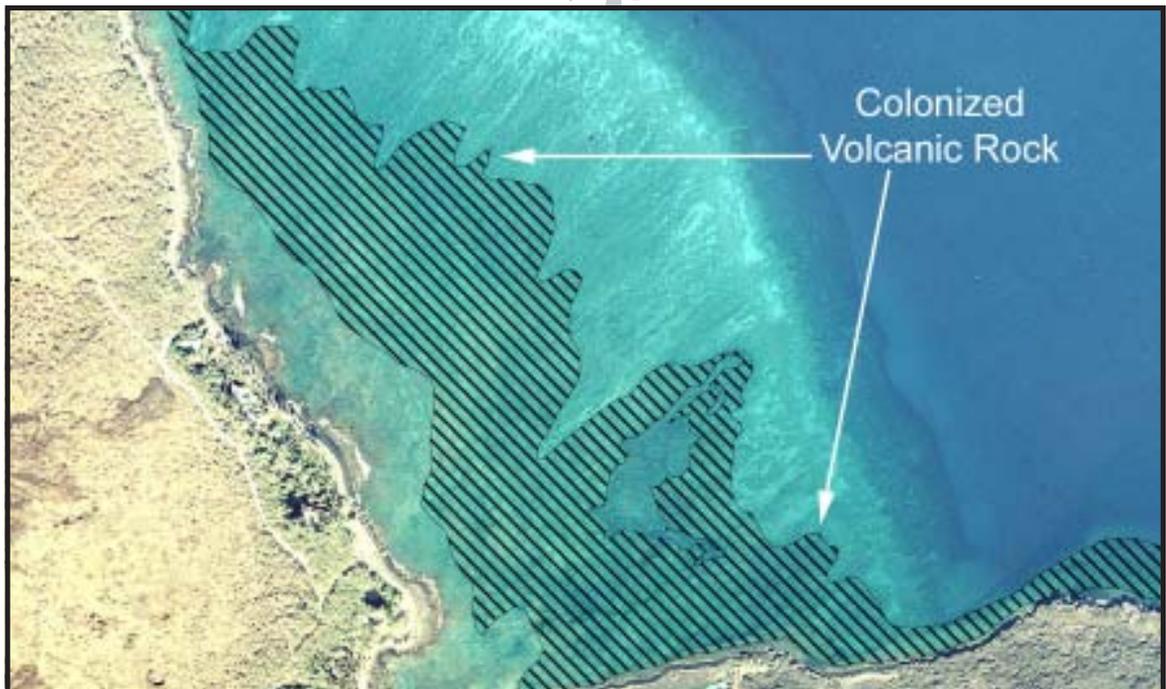


Habitats

Colonized Volcanic Rock/Boulder

Colonized Volcanic Rock/Boulder: Solid volcanic rock that has coverage of macroalgae, hard coral, zoanthids, and other sessile invertebrates that begins to obscure the underlying surface.

Coral Reef and Hardbottom



Habitats

Colonized Pavement with Sand Channels

Coral Reef and Hardbottom

Colonized Pavement with Sand Channels: Habitat having alternating sand and colonized pavement formations that are oriented perpendicular to the shore or bank/shelf escarpment. The sand channels of this feature have low vertical relief relative to spur and groove formations. This habitat type occurs in areas exposed to moderate wave surge such as the bank/shelf zone.

Representative Species/Live

Coral Community:

Porites compressa

Porites lobata

Montipora spp.

Pocillopora meandrina



Habitats

Reef Rubble

Uncolonized Hardbottom: Hard substrate composed of relict deposits of calcium carbonate or exposed volcanic rock.

Reef Rubble: Dead, unstable coral rubble often colonized with filamentous or other macroalgae. This habitat often occurs landward of well developed reef formations in the reef crest or back reef zone.

Coral Reef and Hardbottom

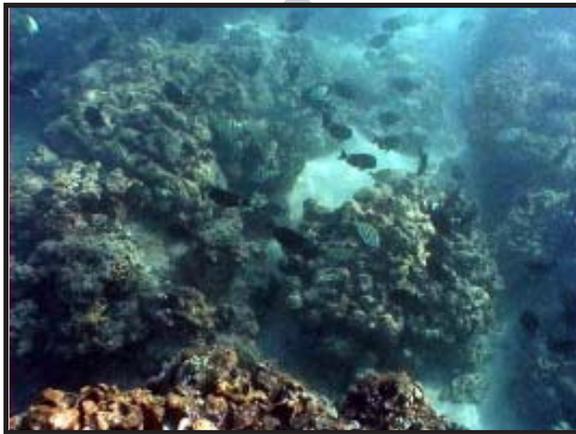


Habitats

Uncolonized Pavement

Uncolonized Pavement: Flat, low relief, solid carbonate rock that is often covered by a thin sand veneer. The pavement's surface often has sparse coverage of macroalgae, hard coral, zoanthids, and other sessile invertebrates that does not obscure the underlying surface.

Coral Reef and Hardbottom



Habitats

Uncolonized Volcanic Rock/Boulder

Uncolonized Volcanic Rock/Boulder: Exposed volcanic rock that has sparse coverage of macroalgae, hard coral, zoanthids and other sessile invertebrates that does not obscure the underlying surface.

Coral Reef and Hardbottom



Habitats

Uncolonized Pavement with Sand Channels

Uncolonized Pavement with Sand Channels: Habitat having alternating sand and uncolonized pavement formations that are oriented perpendicular to the shore or bank/shelf escarpment. The sand channels of this feature have low vertical relief relative to spur and groove formations. This habitat type occurs in areas exposed to moderate wave surge such as the bank/shelf zone.

Coral Reef and Hardbottom



Habitats

Encrusting Coralline Algae

Encrusting/Coralline Algae: An area with 10 percent or greater coverage of any combination of numerous species of encrusting or coralline algae. May occur in shallow backreef, relatively shallow waters on the bank/shelf zone, and at depth.

Continuous Encrusting/Coralline Algae: Encrusting/coralline algae covering 90 percent or more of the substrate.

Patchy Encrusting/Coralline Algae: Discontinuous encrusting/coralline algae with breaks in coverage that are too diffuse or irregular, or result in isolated patches of coralline algae that are too small (less than the MMU) to be mapped as continuous coralline algae.

Patchy Encrusting/Coralline Algae (50%-<90% cover)

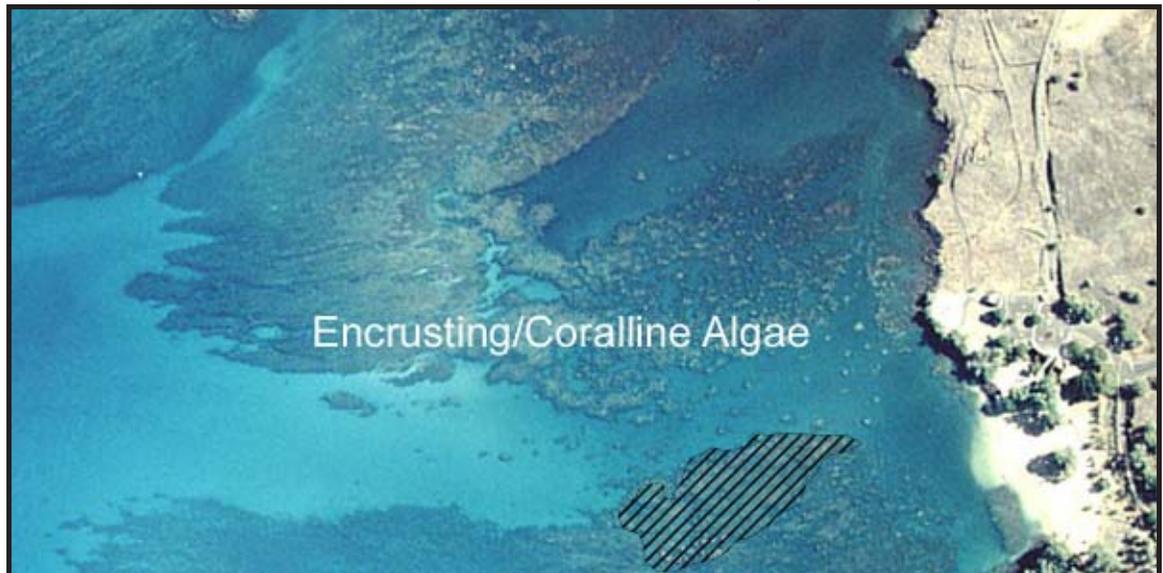
Patchy Encrusting/Coralline Algae (10%-<50% cover)

Representative Species:

Porolithon gardineri



Coral Reef and Hardbottom



Habitats

Emergent Vegetation

Other Delineations:

Emergent Vegetation: Emergent habitat composed primarily of *Rhizophora* mangle (red mangrove) and hao trees. Generally found in areas sheltered from high-energy waves. This habitat type is usually found in the shoreline/intertidal, back reef, or barrier reef crest zone.

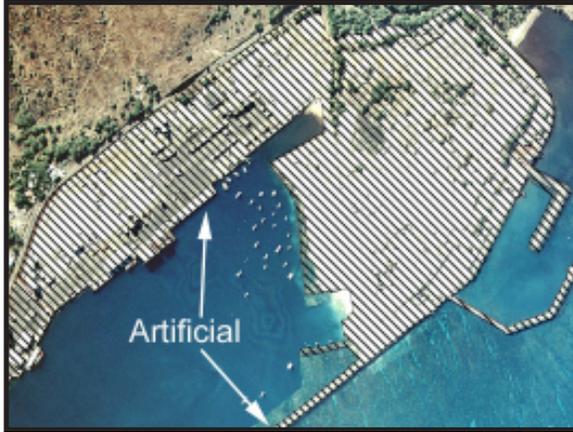
Other Delineations



Habitats

Artificial

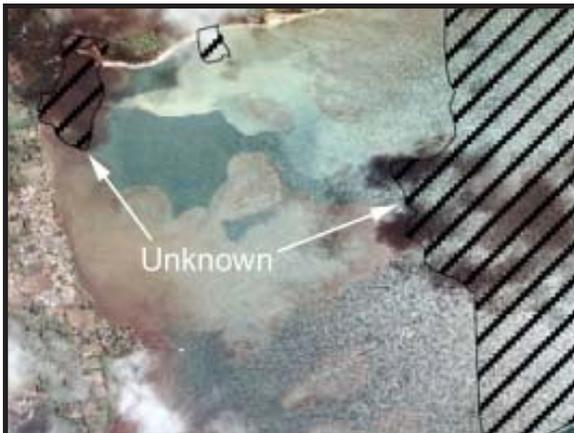
Artificial: Man-made habitats such as submerged wrecks, large piers, submerged portions of rip-rap jetties, and the shoreline of islands created from dredge spoil. Includes active and remnant fish ponds walled off from the open ocean along the shoreline, often along a reef crest.



Other Delineations

Unknown

Unknown: Bottom type unknown due to turbidity, cloud cover, water depth, or other interference.



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The products and ongoing research components of these activities would not be possible without the strong partnerships forged within NOS, NOAA, other Federal Agencies, States, Territories, and Commonwealths. The efforts of NOS's Special Projects Office, National Geodetic Survey, and the Coastal Services Center have been essential to the successful implementation of this program.